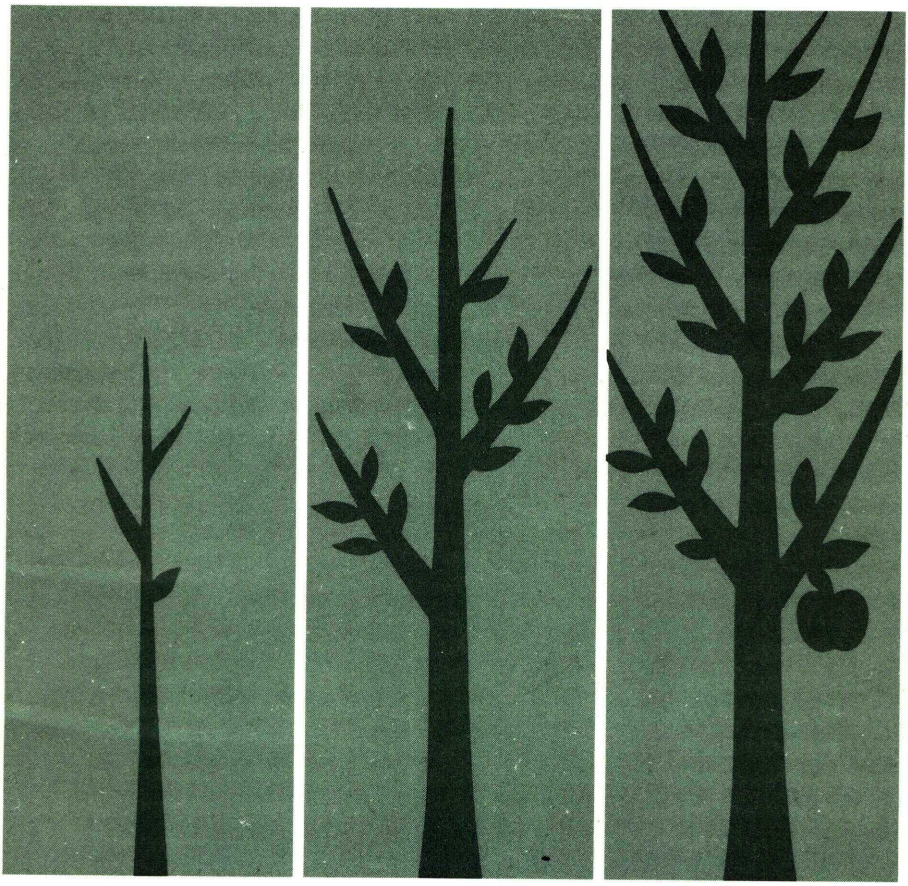
Establishing & Managing Young Apple Orchards



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CONTENTS

On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

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ESTABLISHING AND MANAGING YOUNG APPLE ORCHARDS

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The average life of a commercial orchard for the United States as a whole appears to be not over 40 years. In northern sections, such as New England, New York, and Michigan, where trees develop more slowly, some orchards may last 50 years or more. In sections where the tree develops rapidly, orchards of 35 to 40 years have frequently passed the time for the most economical production of good-quality fruit. Thus, it would appear that most commercial orchards should be replaced at least by the time they are 40 years of age.

Fruit of the best size and quality is invariably produced on relatively young trees. Because of the height of large old trees, it is difficult to spray them thoroughly and expensive to prune them and to thin and pick the fruit. The various regions that have attained reputations for producing high-quality apples made these reputations when the orchards were relatively young. Renewal of the orchard permits the planting of the best varieties and strains. Practically every orchard as much as 35 years old contains a number of varieties that would not be planted today, because they have proved to be inferior as commercial varieties. Also, such orchards do not contain the newer varieties that have proved to be outstanding in recent years.

For these reasons, the apple orchard must be systematically renewed if good-quality fruit is to be produced. Instead of maintaining orchards to as old an age as possible, new acreage should be systematically planted to replace the old, or old orchard sites should be replanted. If orchards are replaced at not more than 35 to 40 years of age, trees can be planted somewhat closer together and production per acre increased during the principal producing life of the trees.

About one-fourth of the life of the trees is required to bring them into good production. A grower who is systematically renewing his orchard will need to have approximately one-fourth of his acreage under 10 years of age in order to bring about such systematic renewal. In the United States, about 12 million trees in this nonbearing or a very early bearing stage would be required to maintain 40 million trees of bearing age in orchards. This bulletin deals with the selection of orchard sites, planning and planting the orchard, and care of this nonbearing orchard acreage.

SELECTION OF SITES

Frost Injury

Too much emphasis cannot be placed on the importance of air

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drainage from the standpoint of apple production. In most parts of the United States, spring frosts or freezes shortly before, during, or after bloom constitute a tremendous hazard to apple production. This hazard can be reduced by selecting the most favorable sites for orchard planting, although in most parts of the United States it cannot be entirely eliminated.

Cold air, which is heavier than warm air, tends to settle into low spots. On still, frosty nights the temperature in valleys or depressions surrounded on all sides by higher land may be several degrees colder than that in more elevated locations. Under such conditions, a difference of 100 feet in elevation may make a difference of 2° to 10° F. in the minimum temperature encountered. In many seasons, such differences would mean the difference between a full crop and a crop failure. The first prerequisite of a site for the apple orchard is that it be sufficiently elevated so that the cold air can settle below the orchard during the cold nights of spring.

Sites above good-sized streams or lakes, that have free opportunity for the cold air to settle from the orchard to the water, are particularly favorable from the standpoint of frost protection. Timber surrounding the lower side of an orchard may tend to collect the cold air into a frost pocket, even though the slope of the land is away from the orchard.

Although it is desirable that the orchard be located on a site sufficiently elevated to secure good air drainage, sites on the tops of ridges may be unsatisfactory from several standpoints. Such sites are exposed to heavy winds, which do much injury to trees and fruits. Wind may also interfere with spraying operations. Exposure to very cold winds in winter may increase the hazard of low winter temperatures. The slopes along the sides of ridges are generally more desirable than the tops.

The location of the orchard on a very steep slope offers a number of problems in the later management of the orchard. On such steep hillsides spraying often becomes a serious problem. Cultivation of steep hillsides may also be impracticable because of the danger of erosion but fortunately the apple thrives well under permanent or semipermanent sod systems. Consequently, if the soil is satisfactory, apple orchards can be planted on steeper slopes than would be satisfactory for other fruits that need cultivation.

Many orchard operations, such as pruning and thinning, harvesting, and hauling of the fruit, are more difficult on steep hillsides than on more level land. However, the excellent air drainage usually found on such sites may more than compensate for problems in management. Many successful apple orchards are located on slopes of as much as 20°. Figure 1 shows such a location, where most of the orchard has excellent air drainage.

Soil

A second consideration equally important in determining where the orchard should be located, is the

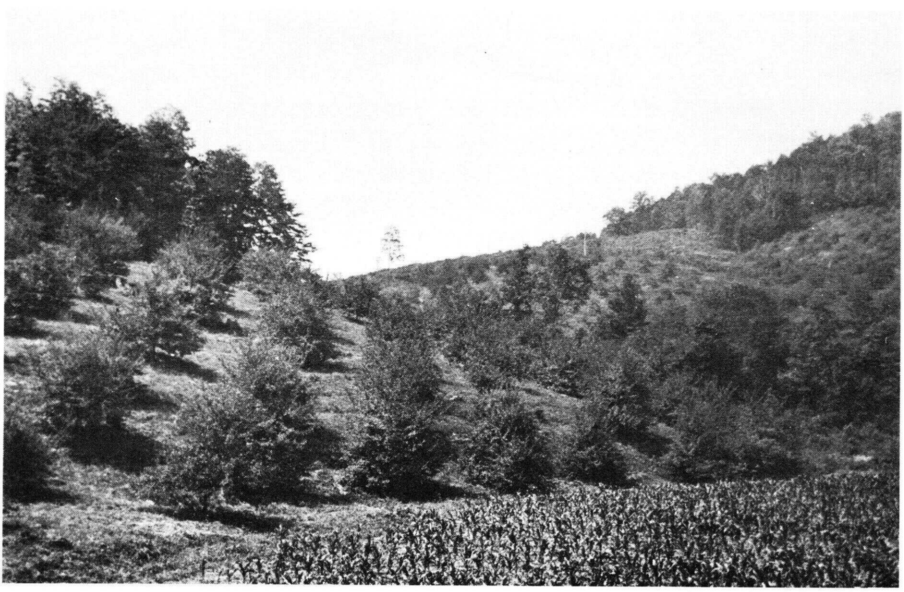

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Figure 1.—Apple orchard on a rather steep hillside. Frost rarely reduces the crop on the trees in the upper two-thirds of the orchard, but frequently it reduces or destroys the crop on the lower trees.

soil. Many orchards have been planted on soils so shallow or so poor that an intelligent examination of the soil would have shown at the start that there was little chance for success. The old idea that soil unfit for other use is satisfactory for an orchard has been costly to many growers. Soils may be too steep or too stony for general farm crops and still be well adapted to orchards. However, the heavy investment necessary for establishing an orchard should not be made on a soil that is not certain to be satisfactory for the purpose.

The most important factors to consider in the soil are—

- Drainage and aeration. Apple orchards usually are not successful on soils that become waterlogged and remain in that condition for any appreciable length of time.
- Waterholding capacity. This includes a consideration of both the texture of the soil and its depth.
- Capacity to absorb water readily from rain or irrigation.
- Fertility.

Soil drainage and aeration

In many soils, the subsoil is so heavy and impervious to water movement that water does not drain out of the ground freely. In such soils, the spaces between the soil particles become filled with water during wet seasons. This water excludes the oxygen of the air, which is essential for root growth and, in fact, for maintenance of life in apple roots.

If the soil has been drained for a period of time and root development has occurred, a period of waterlogging of any considerable duration while the trees are in active growth will result in the death of the roots. The roots can stand some submergence during the dormant period, provided the water drains away by the time growth starts in the spring. Submergence of the root system for even a few days during the summer growing season, when temperatures are high, usually results in the death of the roots.

Consequently, in soils that tend to be waterlogged, the root system of apple trees is usually confined to the relatively shallow surface layers of soil. Although the tendency to become waterlogged is greater in the heavier types of soils, even soils that are sandy and porous on the surface may have a tight subsoil that prevents the drainage of excess water. Poor drainage can frequently be detected by an examination of the subsoil. Poorly drained subsoils in many cases are mottled in color, and have prominent gray streaks and rusty brown spots, which indicate a lack of adequate aeration.

Unless it is clear that the soil is well drained, test holes can be dug to determine whether standing water is present and, if so, how long it stands in the holes in the spring. If water stands within 3 to 4 feet of the surface in such test holes for several weeks after growth starts in the spring, the site is undesirable for orchard purposes.

Even in soils free of standing water, root development is usually sparse and slow in fine-textured soils with limited airspace. Both root growth and top growth of trees are more rapid in open-textured than in fine-textured soils, provided moisture is ample. The ideal fruit soil is one having a moderately open texture, but sufficiently deep and well drained to permit deep rooting. Although available waterholding capacity per foot of depth is less in moderate than in fine-textured soil, this lack is compensated for if the moderate-textured soil is of somewhat greater depth. Thus, moderate-textured soils of good depth and drainage are ideal for apple production.

Waterholding capacity

Any soil will hold a certain amount of water against the force of gravity, which causes the free water in the soil to move downward. The amount of water the soil will hold against gravity is known as the field capacity. It cannot be changed appreciably by any cultural operation. The building up of organic matter in the soil will tend slightly to increase its capacity to hold water, but this is generally limited to a few inches on the surface. Organic matter in the soil is more important from the standpoint of improving water penetration than from that of actually increasing the waterholding capacity of the soil.

In general, the finer textured the soil, the greater the amount of water it will hold per foot of depth. An open, sandy soil will usually hold water not in excess of 10 percent of the weight of the soil. A finer, silt-loam soil may hold 20 to 25 percent of its weight in water. Heavy clay

soils may hold as much as 30 to 35 percent of their weight in water, although such fine soils are likely to be poorly drained, and this is not satisfactory for tree growth.

Not all the water that a soil will hold is available for plant growth. A certain residue cannot be extracted from the soil by plants. In most soils, about half or a little more of the total water the soil will hold is available for plant growth. The amount of water in the soil at the time plants can no longer extract sufficient water to prevent their wilting is known as the wilting percentage of the soil. The amount of water between the field capacity and the wilting percentage is referred to as available water, or the amount of water available for plant growth.

A sandy soil that has a field capacity of 8 percent is likely to have a wilting percentage of 2 to 4 percent, and the available water would equal only 4 to 6 percent of the weight of the soil. In a layer of soil a foot deep, 6 percent of moisture corresponds to a layer of water approximately 1 inch deep over the soil surface, or the amount that would fall in 1 inch of rain. Such a sandy soil 4 feet deep would store up, available for the trees, only 3 to 4 acre-inches of water.

In contrast, a good silt-loam soil with a field capacity of 20 percent and a wilting percentage of 8 would store 2 inches of available water for each foot of depth. For this reason, the sandier types of soils are suitable for apple-orchard planting only when deep and well drained. Approximately twice the depth of soil is necessary in a medium sandy soil as would be necessary in a silt-loam soil to carry the trees through the same period of drought or the same interval between irrigations.

During the summer months, mature apple orchards will use about 4 to 6 acre-inches of water per month, the amount depending on the cover crop and the rate of evaporation. If the soil will hold 8 acre-inches within the root zone of the trees, rainless periods of 4 to 6 weeks will not be very serious. In nonirrigated orchards, such a soil will provide adequate insurance against serious drought hazard in those parts of the country where total annual rainfall exceeds 35 inches. In soils holding less than about 8 inches of available water within the root zone, drought hazard is high, particularly in the warmer parts of the country. Even under irrigation, soils of such waterholding capacity are highly desirable, as the intervals between irrigations can be longer than on soils of limited waterholding capacity.

Water penetration

Good orchard soils take up water readily. This is equally important whether the orchard is to be maintained under irrigation or under natural rainfall. In soils that take up water very slowly, the runoff is likely to be heavy during periods of rain. This not only results in erosion, but, what is equally serious, the water is lost to the orchard. The problem caused by the nonpenetration of water into heavy impervious soils makes irrigation difficult in

many orchards. Therefore, a soil sufficiently open to absorb rainfall or irrigation water is highly desirable. The maintenance of adequate organic matter in the surface soil greatly increases water penetration.

Fertility

In general, waterholding capacity, water penetration, and aeration are more important in site selection than is fertility. Commercial fertilizers can supply the essential nutrients.

Most State experiment stations provide soil-analysis services. Soil samples representative of the orchard site should be analyzed and fertilizers applied in accordance with experiment station recommendations.

Where necessary, sufficient dolomitic lime should be worked into the soil to bring the pH to 6.5. If required, zinc should also be worked into the soil. Because zinc does not move readily in the soil, applications after planting may get to the trees too slowly.

PLANNING AND PLANTING

Planning

Orchard planning requires more foresight than planning for any other crop. To meet increased production costs and the demand for higher quality fruit, orchards must start producing soon after they are planted and continue to produce 20 to 40 years. Each tree must be an easily managed unit that can get the most from the climatic and cultural factors available.

In planning an orchard, a grower must make decisions about such things as the selection of varieties and rootstocks, tree size and spacing, pollination, and planting procedures.

There are several kinds of rootstocks that can be selected for their size controlling characteristics, adaptability to unfavorable soil and moisture conditions, and tolerance to low winter temperatures. Besides these different rootstocks, there is a wide range of varieties, or scions, that can be budded to the rootstocks. These stock-scion combinations can be used with tree spacing, training, and pruning to produce trees that vary in yield potential from 100 pounds to several thousand pounds of fruit per tree.

Presently, trees are planted closer together than they were in the past so they will produce more fruit per acre (fig. 2). Because of this change, work in the orchard is done in the rows between the trees instead of underneath the trees. It is important, therefore, to consider tree arrangement and size carefully so the maximum fruiting area in the orchard can be developed and still leave enough work space between the trees.

In sections of the country where the annual rainfall is less than 35 inches per year and where irrigation is not feasible, it is essential that all of the water that falls be absorbed by the soil, not only to prevent erosion but also to provide sufficient water for the trees. Under such conditions it may be desirable to practice partial cultivation with cover crops in order to reduce the competition between the trees and the cover crops for the limited water

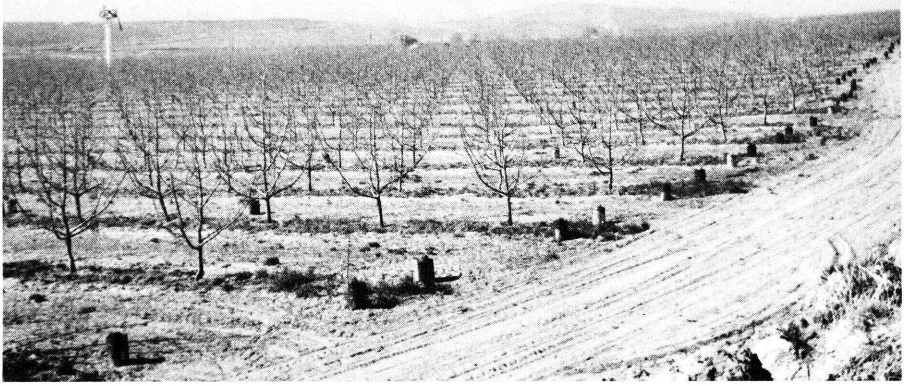

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Figure 2.—Modern orchards are being developed with small trees at close spacing.

that is available. If cultivation is to be practiced in the orchard, particularly through much of the growing season, the trees should be planted so that erosion will be reduced to the minimum. This means planting the trees on the contour or with all those in a row at the same level in the orchard, either with or without the construction of definite terraces at the point of tree planting.

Where conditions appear satisfactory for maintenance of good sod covers in the orchard, the square or the rectangular system of planting is usually desired. In the square system, trees are planted at equal distances from one another in rows running in two directions. In the rectangular system the trees are planted somewhat closer together in one direction than in the other. The latter system provides greater space between the rows in one direction, which facilitates moving through the orchard for spraying, hauling fruit, and other operations, particularly after the trees have attained large size.

Where erosion may be a problem and where the orchard is to be maintained under cultivation, the planting of the trees on the contour on sloping ground has many advantages. Planted on the contour, all trees in a row are in soil at the same elevation. The rows are not straight, but run around the slopes of the hills in such a way as to maintain an approximate level for the trees in any row. Under such planting conditions, cultivating should be done entirely between the rows planted on the contour, and not up and down hill. Cultivation under these conditions tends to build slight ridges at the tree row, which increase absorption by reducing the tendency of the water to run down the slope. Natural, rather low terraces eventually result from such contour planting coupled with contour cultivation.

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Obviously the tree rows are not equally spaced in all parts of the orchard. On the steeper slopes the rows would tend to be closer together, while they would be farther apart on the less steep areas. An orchard laid out by the contour system is shown in figure 3. On steeper parts of the orchard, it may be necessary to drop out parts of rows in order to prevent their coming too close together.

The third method of planting involves the construction of actual terraces prior to the planting of the trees. The site is terraced, as for other farm operations, by throwing up ridges along the contour high enough to collect the water from above. The trees are planted on the ridge of soil forming the terrace. On gentle slopes it may not be necessary to build a terrace for each tree row. In that case, the intermediate tree rows not on terraces are on the contour, and natural terraces tend to develop, as indicated above. Since the terraces are built mainly of topsoil, growing conditions on such terraces are usually very favorable for the young trees. But these terraces are difficult to cross with equipment in spraying, hauling fruit, etc. Figure 4 shows an orchard with a few terraces and with the remaining tree rows on the contour.

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Figure 3.—An orchard planted on the contour, showing cultivation that results in building low terraces in the tree rows.

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Figure 4.—Aerial view of an orchard with a few terraces constructed prior to planting the trees. The rest of the tree rows are on the contour.

Spacing the Trees

The proper distance for setting the trees will vary with the variety and with the fertility and water-holding capacity of the soil. The trees must be sufficiently far apart to allow the sun to hit the lower branches, if fruit of satisfactory quality is to be grown on the lower parts of the trees.

The spacing between trees is the most important factor influencing early production. Regardless of the planting design, enough trees should be planted so the fruiting branches will rapidly fill the orchard space. The chart on page 10 shows examples of several tree spacings and the yields that are required per tree to reach different production goals.

If dwarfing rootstocks or spur-type trees are used, the trees may grow to be only one-third to one-half the size of the normal tree and the planting distances should be correspondingly reduced.

The closer trees are planted together, the more carefully they must be trained to make the planting successful.

In dense plantings of 156 to 272 trees per acre, trees develop into a hedgerow that limits work to one direction. In more dense designs of 340 to 519 trees per acre, very small trees should be grown by using a combination of dwarfing stock and dwarf scion. None of these planting systems are absolutely rigid; row and tree spacings should be changed

independently to fit particular circumstances.

Arrangement of Varieties

In most instances, apple varieties are not sufficiently self-pollinating to be dependably productive if planted alone. Some varieties will produce partial crops under these conditions, but for the most dependable and uniform crop production, provision for cross-pollination must be made. Orchard observations and experimental results indicate that, to obtain the most dependable set of fruit, trees should not be farther than two tree rows from pollinizer varieties.

On the other hand, it is generally preferable to have all of the trees in one row of the same variety. This facilitates harvesting operations, and if special spray programs are desirable for particular varieties they can be applied better if varieties are planted in solid rows.

Where varieties selected are all good pollinizers, from the standpoint of fruit set, two varieties are sufficient for planting. If one variety is a poor pollinizer, as is the case with such varieties as Winesap, Stayman Winesap, Rhode Island Greening, and others, it is desirable to have more than two varieties interplanted in order to obtain an adequate set.

Where it is desirable to plant the bulk of the orchard to one variety, this can be accomplished by planting four rows of the major variety followed by one row of a pollinizing variety and then an additional four rows of the major variety. If the major variety itself is a poor pollinizer, it will be preferable to plant four rows of the major variety, followed by one row each of two pollinizing varieties. If the grower wants to keep the number of trees of pollinizing varieties to the minimum, the two pollinizing varieties can be alternated in one row, although this is not normally the best arrangement. Experience indicates that where the blocks of trees of a variety are more than four rows wide, trees in the interior rows tend

Tree spacing	Trees per acre	Yield required per tree to reach production goals per acre			Years required to reach expected yield
		1000 bu. per acre	1500 bu. per acre	2000 bu. per acre	
ft.		*bu. per tree*	*bu. per tree*	*bu. per tree*	
30 x 30	48	20.8	31.2	41.7	15 to 20
18 x 24	101	9.9	14.8	19.8	12 to 16
14 x 20	156	6.4	9.6	12.8	8 to 12
12 x 18	201	5.0	7.5	10.0	7 to 12
10 x 16	272	3.7	5.5	7.4	6 to 10
8 x 16	340	2.9	4.4	5.9	5 to 10
6 x 14	519	1.9	2.8	3.8	4 to 8

to set fruit more sparingly than the trees next to the pollinizing varieties.

Selection of Nursery Stock

The selection of good nursery stock is the foundation of a good orchard; therefore, every effort should be made to start with the best possible trees.

Nursery trees are sold according to the height of the tree and diameter of the trunk. Standard sizes are given as follows:

Height	*Diameter*
3 to 4 ft.	3/8 to 1/2 in.
4 to 6 ft.	1/2 to 5/8 in.
5 to 7 ft.	5/8 in. and larger

Large size trees usually are best. For interplanting old orchards, use large trees that are either 4 to 6 feet or 5 to 7 feet high. Where new orchards are being established, the 4- to 6-foot or 3- to 4-foot trees are satisfactory. Trees below 3 feet high and 3/8 inch in diameter need special care and should not be used.

Apples are grown on two general classes of rootstocks. They are seedling and clonal. In general, seedling rootstocks produce the largest and strongest growing trees and require the least special care. Clonal rootstocks are used to control the size of trees.

Each category of clonal rootstock is identified by a number. The chart on page 12 shows the sizes and other characteristics of trees that are produced on different rootstocks. The sizes of the trees produced overlap within some of the rootstock categories.

Scion variety, type of soil, and other factors can alter the size of trees to some degree. As a general rule, the more dwarfing rootstocks should be grown on better soils and sites.

In the nursery, seedling stocks are budded only 1 or 2 inches above ground level. When these trees are moved to the orchard, the bud union should be just below or at ground level.

Clonal stocks should be budded 8 to 12 inches above ground and planted in the orchard with the bud union 4 to 5 inches above ground. If clonal stocks are planted with the bud union below ground, the scion variety usually produces roots. The scion variety will then grow from these roots instead of the rootstock and the size-controlling characteristics of the rootstock are lost. When trees on clonal stocks are used, be sure to get high-budded trees so they can be deep planted in the orchard. Low-budded, shallow-planted trees on clonal rootstocks may have trouble staying erect.

In cold sections of the country, the framework of the tree should be of a hardy variety. The framework may consist of the trunk alone or the trunk and a short framework of branches that form the main scaffold of the tree. Hardy frames of this type resist winter injury.

If a hardy framework is needed, trees of a hardy variety should be obtained from the nursery and grown for 1 to 3 years. When a good framework has formed, the desired variety is then budded on it. One or 2 years may be lost to bring a tree into bearing when this system is used, but it is a good practice where winter injury is a problem.

The County agricultural agent or a local nursery can supply information about which varieties are best suited for an area. Some hardy varieties suitable for framework are Antonovka, Beacon, Beautiful Arcade, Canada Baldwin, Charlamoff, Duchess, Haralson, Hawkeye, Heyer 12, McIntosh, Minnesota 442, Ottawa 292, Robusta 5, and Yellow Transparent.

Time of Planting

In the milder parts of the United States where minimum temperatures are not likely to go below 0° F., apple trees may be planted at any time the ground is not frozen during the late fall, winter, or early spring. In the colder sections, late-fall or early-winter planting may result in winter injury.

The roots of apple trees are more tender to cold than other portions. Exposed apple roots may be killed by temperatures of 20° to 24° F. If nursery trees are being handled in winter, it is necessary to use great care to prevent cold injury to the roots.

New root development will occur when the soil temperature is above 45° F. Spring planting, therefore, should be completed as soon as possible after frost is out of the ground, in order to allow some root development by the time top growth starts.

Size of tree	Rootstock	Anchorage of tree in soil	Adaptability of tree to soil
Full size (standard)	Seedling	Very good	All types
Full size and semistandard (¾ standard)	MM 104	Very good	All types but avoid wet sites
Semistandard	MM 111	Very good	All types; tolerates dry or sandy soil
Semistandard	M 11	Good	Most soils are satisfactory; avoid very sandy, heavy, or wet soil
Semistandard and semidwarf (½ standard)	MM 106	Very good	All types
Semidwarf	M VII	Good-fair	All types except light soils
Semidwarf and dwarf (¼ standard)	M 26	Good-fair	Use on good soils; avoid light soil
Dwarf	M IX	Fair	Use on best soils; avoid light soils

If planting is done in the very early spring, trees will grow about as well as after fall or winter planting. In general, the later in the spring the trees are planted the poorer the growth response will be, because of the poor establishment of the new root system when top growth begins.

Method of Planting

It is desirable to dig a hole somewhat deeper and larger than necessary to take in the root system of the tree. Any broken or injured roots should be trimmed off, but the root system should not be reduced more than necessary prior to planting. The roots of nursery trees contain much stored nitrogen and other plant foods, which are used in forming both new root growth and new top growth.

The trees should usually be set at approximately the same depth as they were grown in the nursery. Planting the trees too deep should be avoided, particularly in heavy or rather poorly drained soil. In dry areas, however, it may be desirable to set the trees somewhat deeper than they were in the nursery in order to have the roots in contact with moist soil.

Where distinct soil layers occur and the surface soil is more fertile than the subsoil, it is desirable that surface soil be filled in around the roots. In heavy soils, better root development and better growth have been obtained when well-soaked peat moss was mixed with the soil surrounding the roots. The fact that such benefit has usually not occurred in lighter soils indicates that the beneficial effect is generally due to aeration. It is known that good aeration is essential for the best development of apple-tree roots. If peat is used, it should be soaked in water, as dry peat will take up water slowly from the soil.

The soil should be packed firmly around the roots in order to establish good contact. If the planting has been done a month or 6 weeks before top growth would normally begin, the young roots should have pushed into the soil before much top growth starts. In most sections, there will be ample moisture in the soil at the time the planting is done; but, should the soil be dry, the soil surrounding the roots should be soaked after planting.

SOIL MANAGEMENT

Although mature apple trees will thrive well in permanent grass or other sod culture, young trees should be protected from competition with other vegetation until they are well established. The roots of young apple trees are not deeper in the soil than the roots of grass or weeds, and if such plants are permitted to grow near the trees they will compete with them for water and nutrients and greatly reduce their growth rate.

It is essential that the soil be so managed as to prevent the competition of other vegetation near the trees during the first few years they are in the orchard. This is most commonly accomplished by cultivation, either with or without the use of intercrops between the tree rows. In many sections of the country, herbicides are being used successfully

to control competing vegetation around young trees.

Cultivation, Cover Crops, and Intercrops

Probably the most widely used method of handling apple orchards during the first few years is cultivation of the whole area between the trees, with seeding of cover crops in midsummer to late summer. These cover crops should be allowed to grow until the growth on the trees is well started in the spring. They are then disked into the soil and the orchard cultivated just enough to prevent excessive weed growth during late spring and early summer. In July or early August a new cover crop is planted. None of the organic material grown in the orchard is removed, and there is no income from the land until the trees begin to bear. The cover crop should be fertilized if necessary to promote good growth.

Such a system of handling is very satisfactory from the standpoint of tree growth. Where trees are interplanted with so-called filler trees, which make a minimum distance between the trees while the orchard is young, the system of using cover crops is generally more satisfactory than attempting to grow intercrops between the tree rows, since the area that could be devoted to intercrops between each two tree rows would be relatively narrow.

In most parts of the United States, rye is particularly satisfactory as a winter cover crop. It is so hardy that it is rarely winter-killed, and it forms a heavy top growth and a surface mat of roots, which is very effective in reducing erosion. Where winters are not too severe, a mixture of vetch and rye is very satisfactory. A good system for young apple orchards is to disk next to the trees by the time the rye heads, and to allow the rye in the centers away from the trees to ripen before disking, as the riper rye is much more valuable for increasing the organic-matter content than that disked in while still green and succulent. Seeding should be done early enough in the summer to insure a dense cover on the soil before cold weather stops growth.

Where a heavy cover crop is incorporated into the soil each spring, the loosening of the soil and the additional organic matter that result tend to reduce greatly the amount of erosion. On moderately steep slopes, however, and particularly in areas where heavy summer rains may occur, cultivation during the early summer may result in too much washing to be satisfactory, even though heavy cover crops have been disked in. Under such conditions permanent sods with strip cultivation along the tree rows, or mulching around the trees, as discussed later, is more satisfactory.

Frequently a young orchard, if on a fairly level site and in good soil, can be interplanted for a few years with cultivated crops, such as potatoes, peas, beans, cabbage, and strawberries. Where such crops are used, it is desirable not to have the rows nearer than 5 to 6 feet from the tree rows during the first 2 years, with increasing distance as the trees become older. The areas between the tree rows and cultivated

crops should be kept cultivated during the spring and early summer. If the site and soil are such that erosion does not occur, tree growth under such conditions is usually very satisfactory. This is particularly true if cover crops and fertilizers are used to maintain the fertility of the soil.

In some parts of the country, alfalfa, clover, or grass may be grown to excellent advantage between the young trees. With these crops also, in order to maintain growth, it is desirable that strips adjacent to the trees be kept cultivated or that other provision be made to prevent competition close to the tree (fig. 5). With such sod crops, the cultivated strip on each side of the tree rows should be at least 5 to 6 feet wide during the first 2 years and should be gradually widened as the trees become larger. Such strip cultivation should be continued until the trees reach bearing age; after that, shading is usually sufficient to prevent heavy growth of the sod crop near the tree trunks.

Occasionally, leafhoppers may injure young trees when alfalfa or clover is grown in the orchard. These crops are favorite hosts for leafhoppers and large populations may build up in them. The hoppers then may severely puncture young branches of fruit trees in egg lay-

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Figure 5.—Wide cultivated strips adjacent to tree rows in young apple orchard. Center strips are alfalfa.

ing. Such damage rarely occurs if alfalfa and clover are kept well away from young trees.

Mulching

An alternative to cultivation along the tree rows in young orchards is mulching around the trees with straw or other vegetable matter. To be effective, such mulches must be heavy enough to prevent the growth of weeds or other vegetation around the tree. They should cover an area extending at least 3 to 4 feet out from the trunk during the first 2 years and continuing out to beyond the spread of the branches as the trees increase in size. Such mulches should be 6 to 8 inches thick when applied and should be renewed often enough to keep down competitive vegetation.

The use of an organic mulch having a relatively high nitrogen content not only will do everything a cover crop will do, but will do it better because this type mulch tends to release essential nutrients in the proper balance for ideal tree growth and production.

In orchards maintained in grass or legume sods, ample mulching material often can be obtained by mowing, raking up the mowed material, and piling it around the trees. On fertile soil, only a part of the material grown in the orchard is necessary to maintain such a mulch, and the remainder may be used as feed without injury to the development of the orchard.

Under mulches, roots tend to develop abundantly near the surface of the soil. However, the tree as a whole is no more shallow rooted under mulch than under other methods of soil management, as many roots will also penetrate down into the soil if it is sufficiently open, regardless of the type of surface treatment. Mulching is particularly satisfactory for orchards located on steep slopes or in rocky soil where cultivation is difficult or likely to cause erosion. Mulching with high-nitrogen hay may be especially effective in overcoming the serious effects of poor drainage and other unfavorable soil conditions.

Where mulches are used, particular precaution must be taken to control mice. Both field and pine mice are attracted to mulches, and they will eat bark from the tree trunk and roots. In early fall, the mulch should be removed from immediately about the trunk of the tree, back for a distance of at least a foot and a half. If mice are present, systematic poisoning or other control measures also should be practiced.

Hand cultivation immediately around the trees may be used instead of strip cultivation or mulching, under conditions where the orchard is maintained in sod and strip cultivation or mulching is not used. Such a system involves much handwork, as competing vegetation must be kept down for a distance of several feet from the tree, and working at least two or three times each season is desirable.

Fertilization

In most parts of the United States, nitrogenous fertilizers should be added to promote the best growth of the trees. In many loca-

tions, particularly on heavily leached soils, additions of potassium, magnesium, calcium, and boron may also be required for normal growth of trees and production of high quality fruit. Requirements for these nutrients should be based on analysis of the soil.

The amount of nitrogen that should be applied will, of course, vary with the age of the tree and with the management practices being followed. It is usually undesirable to add mineral fertilizer before the tree has become established and started growth. One-tenth pound of actual nitrogen, in the form of ammonium nitrate, nitrate of soda, or ammonium sulfate, scattered over an area within 3 feet of the trunk and applied after growth has started in the season of planting, will usually prove beneficial. This amount may be increased as the tree grows older; about one-tenth pound per tree for each year of age of the tree is usually satisfactory. If mulches are used, the quantity of nitrogen can be reduced as the mulch begins to decay. On the other hand, if grass or other sods are growing near the tree, the amount of nitrogen should be increased.

In general, on soils tending to be alkaline, the acid-forming nitrogenous fertilizers, such as sulfate of ammonia, are preferable. On acid soils, the forms of nitrogen that leave an alkaline residue, such as nitrate of soda or calcium nitrate, are to be preferred. Ammonium nitrate is generally the preferred form on soils that are neutral or slightly acid.

The objective in soil-management practices during the early life of the orchard should be to maintain or build up the organic-matter content of the soil to prevent erosion, and to retain as much available moisture as possible for the growth of the tree. The faster the tree grows during the early years of its life, the earlier it will come into production and the greater the amount of fruit it will produce at a given age. The growing of cultivated intercrops will tend to deplete the organic matter rather than to increase it unless these crops are coupled with overwinter covers, which are turned into the soil.

Maintenance of the orchard in sod with strip cultivation or mulching around the trees will tend to increase the organic-matter content of the soil and improve the basic fertility. Cultivation of the whole area during early summer, followed by turning a good cover crop into the soil in the spring, should maintain and, in most cases, increase the total organic matter in the soil.

TRAINING AND PRUNING

Pruning to train the tree and pruning to develop branches for fruit should be considered as two separate operations. Training the tree is pruning to shape and form its structure. Later pruning develops and maintains fruiting wood within this established structure.

Training a Tree

When the spacing between trees is wide, they must be trained to grow into large spreading trees that will fill the space between them.

With large trees, strong trunk and limb structure are very important because each limb may carry several hundred pounds of fruit.

When trees are planted close together, the purpose of training changes. The structure of each tree must be maintained in its small assigned space, but the framework should be trained so that permanently positioned fruiting wood can develop.

In general, this early shaping of the tree should be accomplished with the smallest possible amount of pruning. Much experimental work has shown that the more severe the pruning of the tree prior to bearing age, the more production is delayed and the smaller the tree will be at any given age. Trees that receive little pruning from the time of setting until they reach bearing age are almost invariably larger and fruit earlier than heavily pruned trees of the same age. Since pruning tends to be a dwarfing process and to delay bearing, shaping of the tree during its early life should be accomplished with the minimum amount of cutting (fig. 6).

Pruning the tree during the first 4 or 5 years it is in the orchard is more important from the standpoint of determining its structure and strength than any later pruning. From the time the tree is started, it is necessary for the grower to have in mind the general type of tree that will have maximum strength in the framework branches and will support a crop of fruit with least breakage.

At the beginning of the 20th century, the so-called open or vase-type tree was much in favor. In building this type of tree, the main scaffold limbs were taken from near one point on the trunk. The natural central leader of the tree was removed, and several more or less equal limbs were developed. It was thought that this type of tree would expose the

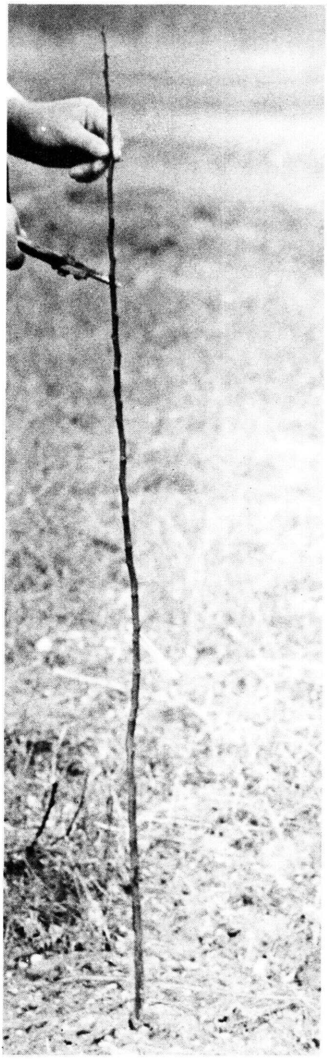

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Figure 6.—A 1-year Stayman Winesap apple tree being pruned immediately after being planted.

maximum fruit surface to light and thus improve the quality.

It was found, however, that such trees were very weak structurally, since the scaffold limbs originating at one point tended to form crotches that split apart when heavy loads of fruit developed; also, heavy pruning was required to maintain the tree in this form, and the total bearing capacity was reduced. Consequently, in more recent years, apple trees have been pruned almost exclusively to the leader or modified leader type. This gives a stronger tree structurally with greater bearing capacity. Most of the fruit in any case is borne on the outer part, or periphery, of the tree, so that the crop is as well exposed to light with this type of tree as with the vase form.

The leader type of tree is one in which a central trunk is maintained. The limbs branching off from this main leader should be smaller at the point of union than the leader branch. Such a union has been found to give the strongest possible type of crotch.

Also, the wider the angle made by the side branch from the central leader, the stronger the resulting crotch. Branches making narrow angles tend to split out, whereas branches from a larger leader, making wide-angle crotches, almost never split. Such branches may break from a heavy load of fruit, but they do not split out from the main trunk.

Tree training should not be left to chance. When it is neglected, "corrective pruning" becomes necessary to remove undesirable branches. During the period of training, careful attention must be paid to (1) early selection of framework branches, (2) the use of proper pruning cuts to adjust tree growth, and (3) the spread of lateral branches into the horizontal position.

The early limb selection pictured in figures 7 and 8 shows the cutting necessary at the end of the first year to avoid heavy cutting when the tree starts bearing. This method of pruning directs growth into desirable branches that will be maintained for the life of the tree.

To correctly develop the tree, the two types of pruning cuts usually made are heading cuts and thinning cuts. Heading cuts remove part of a 1-year-old shoot to a lateral bud. These cuts leave a stub. Heading

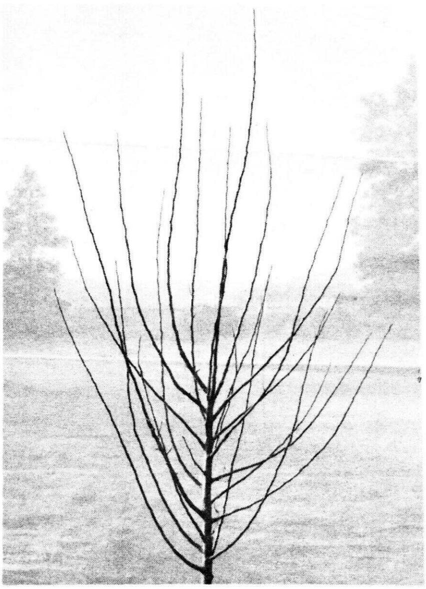

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Figure 7.—A well-grown Red Delicious following its first year's growth.

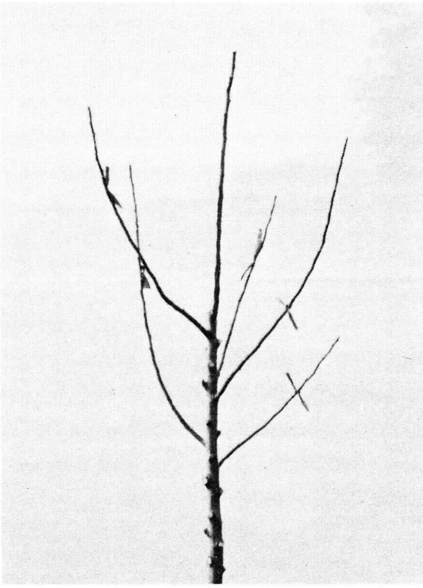

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Figure 8.—This is the same tree shown in figure 7 after the first dormant pruning. Note the early selection of framework branches and maintenance of the central leader.

stiffens the branches and promotes the growth of shoots from the buds at the end of the stub.

Thinning cuts are made into 2-year-old or older wood; the entire branch is removed at its point of origin. A thinning cut controls or reduces the growth of branches and encourages fruiting. When heading cuts and thinning cuts are made either separately or in combination, the growth of the tree can be controlled as desired.

In addition to the early selection of framework branches and the use of proper pruning cuts, it is essential that the lateral branches are spread to about a 45 degree angle to the trunk. When the limbs are spread, full advantage can be taken of the desirable characteristics of horizontal branches.

The benefits of spreading are shown in figures 9 and 10. Both trees have a central-leader framework, are the same age, and have the same rootstock-scion combination. These 6-year-old trees on MM106 rootstocks produced 4 to 8 bushels of fruit when they were pruned to develop a proper framework and the branches were spread. Upright trees had fewer apples.

For a successful job of spreading, the right material must be used. Stiff wires, 6 to 12 inches long and sharpened or cut at an angle, work well on small branches. Wood

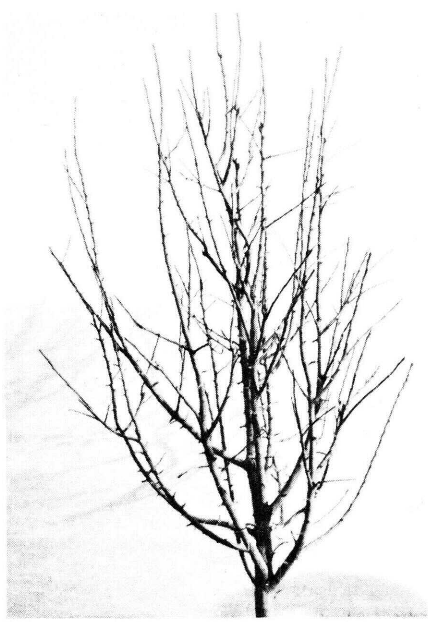

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Figure 9.—A 6-year-old spur type Red Delicious on an MM106 rootstock. This tree was trained to a central leader but the branches were not spread. Note the crowded branches, the lack of fruiting wood, and the small area occupied by the tree.

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Figure 10.—A tree the same age and variety as shown in figure 9. This is a central leader tree that has been spread since its second growing season. Note the open branches in the center of the tree, the large amount of fruiting wood, and the large area occupied by the tree.

spreaders with nails in both ends work best on large branches.

Training a young tree is simple if the tree is considered in sections according to age (fig. 11). Each section should be trained according to the age of that section and not by the age of the entire tree.

Pruning in each section is determined by the age of the section being pruned, the number and length of branches, and the desired direction of growth. Heading cuts are made in 1- and 2-year-old sections to promote the growth of side shoots.

In the 3-year-old and older sections, pruning should be shifted to thinning cuts to reduce the number and length of branches and to promote fruiting.

At planting time, trees should be headed severely. Severe heading encourages the development of a large number of vigorous, wide-angled branches. Most of the first-year branches will grow within 10 to 12 inches from the point where the tree is headed. The lower a tree is headed, the more buds grow on the remaining part of the trunk.

Pruning for Fruit

Pruning the trees during the dormant season after the first year's growth is very important. The tree then has a 1- and 2-year-old section. In the 1-year-old section, select the central leader and remove all competing shoots; these are thinning cuts. Head the central leader severely enough to produce side shoots where you want them. Do not be in a hurry to get a tall central leader tree. Concentrate on developing the lower fruiting branches first and then build the tree upward.

In the 2-year-old section, remove the strong shoots and leave the weak ones because strong shoots will com-

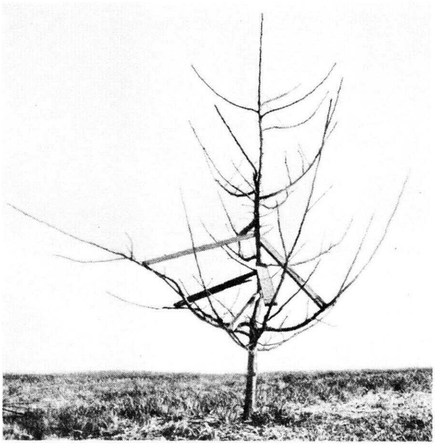

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Figure 11.—A 4-year-old tree after pruning.

pete with the central leader. Select the permanent lateral branches and remove the rest. Five laterals are the ideal number in apple trees (fig. 12).

After selecting the laterals, head them to stiffen them. As a rule of thumb, cut off about one-fourth of the past season's growth. Heading is very important because it keeps branches growing vigorously. Even vigorous-growing branches tend to set flowerbuds. If the flowerbuds are not removed, the lateral branches will grow very little.

Pruning in the dormant season at the end of the second year's growth is done the same way the pruning was done on the 1- and 2-year-old sections at the end of the first year's growth. In other words, always prune the 1- and 2-year-old growth at the top of the tree as if the tree were only a 2-year-old tree.

The 3-year-old section of the tree,

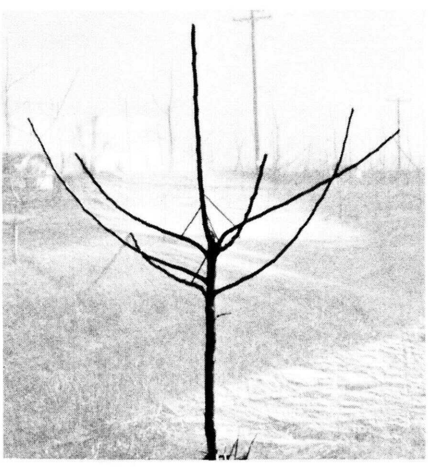

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Figure 12.—A tree pruned after its first season's growth. Framework branches have been selected, headed, and spread.

at the end of the second year's growth, contains 2-year-old laterals. Prune these the same as the central leader. Remove crowded shoots, head the leader, and select side shoots for future fruiting. Remove all shoots that are growing straight up from the lateral branches and those shoots growing from the bottom of the branches. All large, rapidly growing shoots should be removed, moderately growing shoots should be headed, and small shoots should be left unheaded (fig. 13).

At 2 years of age, most of the initial spreading begins. Spreaders are often hard to keep in place in 1-year-old branches but 2-year-old branches hold spreaders well.

By the end of the third year's growth, depending on planting distance and size of the trees, some laterals may have reached their full spread. At this time, start changing from heading cuts to thinning cuts. If no further growth of branches is needed, crowded branches should be thinned. If a branch is cut back to a downward growing shoot, growth of the branch will be greatly reduced and further spread stopped. If the limb still needs further stiffening, heading cuts should be used.

As the tree develops further, be sure the upper branches are always shorter than the ones below so light can get to the lower branches. The tree will be coneshaped with most of the fruiting area in the lower part of the tree. If the central leader is headed severely each year, the tree will grow only a foot or two each year. As a result, the tree should be 5 to 9 years old before it

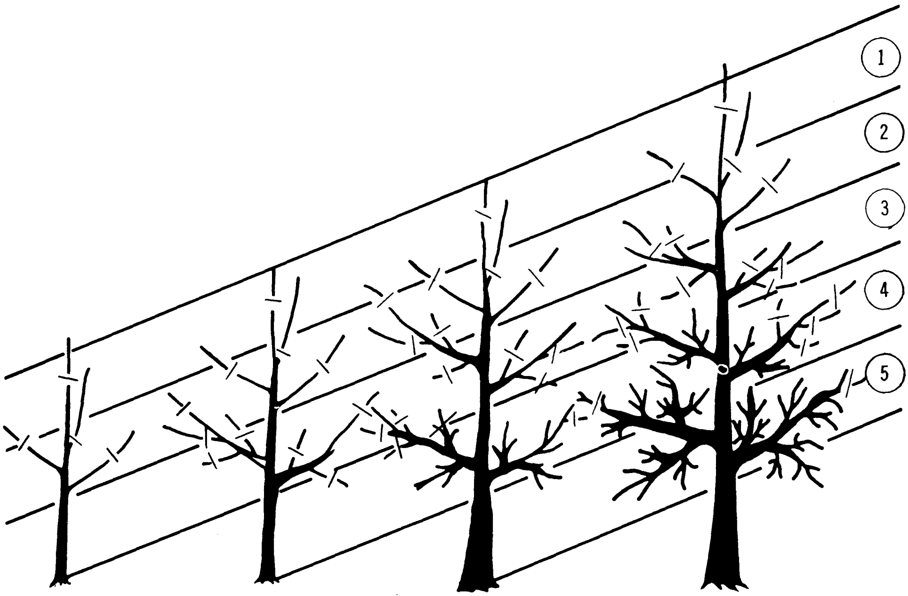

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Figure 13.—The method used for training trees in sections according to the age of the wood in each section.

reaches its full height. At this age, the tree should be fruiting quite heavily, which will slow down the top growth (fig. 14).

If a tree grows too rapidly to its final height, top growth will be hard to control. When growth has not slowed down because of heavy bearing by the time the tree reaches the desired height, keep heading the leader back into 1-year-old wood. The proper rootstock-scion combination should help keep the tree within proper size.

The advantage of close-planted trees can be quickly lost if the tops get too large and shade out the lower sections. If the central leader is maintained, it is important each year to cut back the 1-year-old section at the top of the tree to a few buds.

Do not use mechanical tree hedgers as pruning aids on young apple trees. Continued use of these machines produces only upright growth of the branches rather than fruitful spreading growth. The top growth increases two or three times each time the top is mowed and this growth shades out the fruiting wood.

WEEDS

Good weed control reduces the danger of mouse damage by eliminating the cover around the base of the trees, reduces competition from weeds for water and nutrients, and may reduce insect and disease damage because weeds may serve as alternate hosts. The use of herbicides to control weeds is preferable

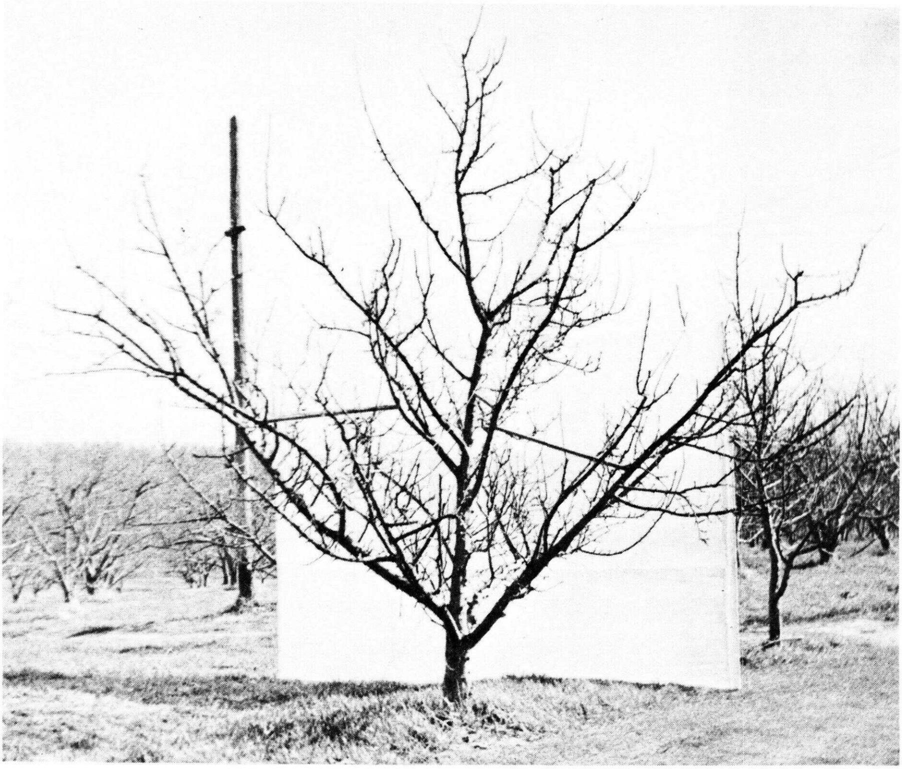

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Figure 14.—A 15-year-old spur type Delicious central leader tree.

to mechanical cultivation. One or two herbicide applications per year usually will control weeds. Mechanical cultivation cuts roots in the surface area and close cultivation often damages the tree bark.

The weed-free area should extend 3 to 4 feet on each side of the trees and should be increased as the trees grow. When standard trees are planted in square or rectangular spacing, herbicides usually are applied in square patterns around the trees. For dwarf and semidwarf stock planted in close spacing, herbicides usually are applied in continuous strips.

Weeds may be controlled with preemergence or postemergence herbicides depending on the weed problem. Preemergence herbicides are applied to the soil before weeds appear; postemergence herbicides are applied to the weeds after they appear. Herbicides that may be used are discussed in the following lists.

Some preemergence herbicides are as follows:

Diuron [3-(3,4-dichlorophenyl)-1,1-dimethylureal].—Do not apply until trees have been established at least 1 year. Do not use in plantings of dwarf varieties.

Simazine [2-chloro-4,6-bis(ethylamino)-*s*-triazine].—Do not apply

until trees have been established at least 1 year.

Dichlobenil [2,6-dichlorobenzonitrile].—Apply after trees are established. For best results, apply in fall or early spring when temperatures are low.

Terbacil [3-*tert*-butyl-5-chloro-6-methyluracil].—Do not apply until trees have been established at least 3 years.

Diphenamid [*N*, *N*-dimethyl-2,2-diphenylacetamide].—Apply shortly after planting.

Paraquat [1,1′-dimethyl-4,4′-bipyridinium salts] may be used as a postemergence herbicide.

The preemergence herbicides diuron, simazine, dichlobenil, and diphenamid will kill germinating annual weeds such as crabgrass, goosegrass, pigweed, lambsquarters, and others. At agricultural rates listed on the container label, they will give residual weed control for about 3 to 6 months. They generally are not effective on established weeds.

The postemergence herbicide paraquat will kill small established annual weed grasses, broadleaf weeds, and the tops of perennial weeds. Paraquat is a contact herbicide and does not give residual weed control.

DISEASES

Diseases requiring attention in young apple orchards are usually those that interfere with tree growth and development. Scab, black rot, powdery mildew, and rust are the principal diseases that need to be controlled. Chemical sprays are suggested rather than dusts because sprays are more effective and last longer.

The number of applications needed depends on the area where the trees are planted. Humid areas require more frequent applications than drier areas. Spraying should begin when older trees are in full bloom and repeated at 2- to 3-week intervals, or as needed. All chemicals should be applied in accordance with directions on the container label.

Some apple diseases and their control are listed as follows:

Apple scab.—Use captan, dodine, or glyodine.

Black rot.—Use captan.

Powdery mildew.—Use sulphur or dinocap.

Rust.—Use ferbam or zineb.

INSECTS

Nonbearing apple trees are not attacked by insects as severely as are bearing trees. Chewing insects, aphids, mites, scales, and leafhoppers are the most serious pests of young apple trees. Malathion controls aphids, leafhoppers, and yellow necked and red humped caterpillers; carbaryl controls red banded leaf rollers and cankerworms; dicofol or ethion controls mites; and parathion or dormant oils control scales. Follow directions on the container label when using insecticides.

For further information on insect pests of apples, see Home and Garden Bulletin 190, "Insects on Deciduous Fruits and Tree Nuts in the Home Orchard." It is available from the Superintendent of Documents, U.S. Government Printing

Office, Washington, D.C. 20402, at 70 cents a copy.

USE OF PESTICIDES

This publication is intended for nationwide distribution. Pesticides are registered by the Environmental Protection Agency (EPA) for countrywide use unless otherwise indicated on the label.

The use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by EPA. According to the provisions of the act, "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12(a)(2)(G))

EPA has interpreted this section of the act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State agricultural experiment stations, or county extension agents for information applicable to their localities.

The pesticides mentioned in this publication are available in several different formulations that contain varying amounts of active ingredient. Because of this difference, the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound of active ingredient equals 2 pounds of a 50-percent formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers. Use only pesticides that carry one of these registration numbers.

USDA publications that contain suggestions for the use of pesticides are normally revised at 2-year intervals. If your copy is more than 2 years old, contact your Cooperative Extension Service to determine the latest pesticide recommendations.

The pesticides mentioned in this publication were federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

PROTECT

Use Pesticides Safely

FOLLOW THE LABEL

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